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THE TYPE "M" KITE BALLOON HANDBOOK

NAVY DEPARTMENT

BUREAU OF CONSTRUCTION AND REPAIR

OCTOBER, 1919

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PLATE 1.—The type *M* kite balloon in flight.

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THE
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PREFACE.

The purpose of this book is to give as concisely as possible those facts, regarding the methods and details of construction of the *M* type kite balloon, which will be of most value to the personnel charged with the operation or maintenance of balloons of this type. It is intended to be a reference book which may be used in the training of new pilots, in the acquainting of pilots of experience in other types with the special features of this type, and as a reminder of the various important items which must be kept in mind in the handling of the balloon.

Although fairly comprehensive it should not be considered either as an infallible guide for all conditions or as a substitute for practical service training.

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CHAPTER I.

THE TYPE "M" KITE BALLOON.

INTRODUCTION.

The value of balloons for observation purposes in warfare has been recognized and utilized for many years. At first, the common spherical balloon was used and was controlled by means of a rope or cable connecting the balloon with the ground. The first record we have of a balloon being used in this manner dates back to 1794 when the French Army used several of these balloons during the Revolution.

Such balloons were known as captive balloons and were used intermittently during our Civil War, the Spanish-American War, the Franco-Prussian War and the Boer War. On account of the spherical form the basket could not be held in any fixed position with regard to the wind. Because of the constant swinging they were ineffective and unsatisfactory and were never used to any great extent.

In 1893 Capts. Parseval and Sigsfeld produced at the Berlin works of the Prussian Balloon Battalion the predecessor of the *Drachen* balloon. This was the first real kite balloon flying like a kite with a fairly constant angle and direction relative to the wind and remained practically unchanged until the beginning of the war of 1914–1918.

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At the outbreak of the war, Belgium was practically the only one of the allied nations which made serious use of kite balloons. France and Great Britain possessed the equipment but made small use of it to begin with. The Belgian Army, however, used its small equipment with great effectiveness and the other nations were quickly convinced of its value and increased their equipment. The British Royal Naval Air Service produced its first kite balloon in March, 1915. There were many undesirable features in the *Drachen* balloon however, and the British and French set out to remedy these. In this effort Capt. Caquot, then chief of the balloon section of the French Army, constructed a long series of experimental kite balloons each known by a letter of the alphabet assigned to the successive models. The type *P* and type *R* were so successful that they have been built in hundreds.

The original spherical captive balloon could not be used with any success except in comparatively calm weather. It was limited in the altitude it could attain and, having no ballonet, upon loss of gas it lost its shape. The *Drachen* which succeeded it consisted of a cylindrical envelope with hemispherical ends and was fitted with a ballonet. At the tail of the envelope was a set of lateral sails or fins attached to the sides, one cone shaped funnel or "scoop" on the under side, and a series of tail cups suspended at the extreme end. The fins and tail cups were intended to steady the balloon and the scoop to supply air to the ballonet and help the riding qualities. These new features were a decided improvement. The elongated shape helped to reduce the swaying motion, the fins and tail cups steadied the balloon and kept it headed into the wind and the ballonet maintained a fairly constant gas pressure in the envelope. However, there was still much to be desired.

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In trying to improve the balloon, an attempt was made to do away with tail cups, flapping sails and other protuberances which would offer resistance to the wind. Other radical innovations were also tried such as building balloons with a flexible envelope which would take care of gas expansion and contraction and thus do away with the ballonet. Some balloons were built with rigid cloth covered wooden fins attached on each side to steady the balloon, and many experiments were made comparing the patch with the band method of suspension. New types of valves were used located in every conceivable place and innumerable systems of rigging were tried out. The result of all this experimenting led to the practically universal adoption of the Caquot balloon.

The Caquot type *R* balloon was used alike by the British Army and Navy for a considerable time, but it was found through experience that the requirements of the two services were quite different. A naval balloon is not required to operate at as high altitudes as an Army balloon but on the other hand it receives rougher usage and is subject to higher winds.

For these reasons the type *R* balloon was modified and redesigned by the British so as to meet the requirements for naval use. This balloon is known as the type *M* and is the balloon discussed in this book.

The first kite balloons used in the American Navy were the Goodyear type *C* and *J*, tried out in the summer of 1917. Both were developed from the German *Drachen* balloon. Both the *C* and *J* used tail cups strung on a rope like a kite tail to prevent yawing and diving. The *J* had also small fixed biplane surfaces on either side as stabilizers. These balloons had too much resistance to be practicable in the high resultant winds occurring in naval work and stability was far from ideal.

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In the summer of 1917 a British type *M* (*M–10*), adapted from the French Caquot, was brought to the United States and tested. It was realized that this design was fundamentally superior to the existing American type, and 50 balloons, nearly copies of the *M–10*, were made. Due largely to failure to grasp fundamentals of valve mechanism and detail faults in the design itself, inexperience on the part of operating personnel, and prejudice against balloons in the fleet, experience with these balloons was unsatisfactory, considerable numbers of them being lost in high winds.

On information from various sources that the French *R* was the best development of the accepted Caquot type, a copy of the French *R* built somewhat heavier for naval service was adopted for production, and this was the model that saw most of the active service. After a good deal of discussion and trials of various arrangements, the Gammeter 18-inch poppet type valve was adopted for the *R* instead of the internal-opening French system. These kite balloons gave fair service in medium winds, but, due to the fixed rigging (no pulleys in the crows feet of the suspension), the valve gear was unsatisfactory in very high winds, as the high wind pressure would cause the valve once opened to blow continuously and the fixed rigging would give way in violent yawing when handled on the ground in strong winds.

Winches were also unsatisfactory in that foreign practice of taking strain off the cable before spooling up was ignored and cables (particularly with telephone wire centers) were damaged quickly. This was corrected subsequently, but the improved winches did not get into service in the fleet during the war.

During 1918 several types of smaller balloons were built and tried out. Before these experiments were concluded detailed information on latest British practice

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became available through Maj. R. H. Nicholson, R. A. F., who demonstrated a late British type *M* at Rockaway in July, 1918. The majority of officers concerned were convinced that this new type *M* was the best type available for Navy purposes. With the exception of an improved valve mechanism (still inward opening) this balloon was of the same general design as the old *M*, but had a great many detail improvements. It was adopted for the American Navy and production switched to this type from the *R* as quickly as possible. Due to the signing of the armistice only 20 were built.

These new type *M* balloons of 32,800 cubic feet capacity (the *R* being about 37,000 cubic feet) did not see active service during the war, but were tried out during fleet maneuvers at Guantanamo during the winter of 1918–19 and found a little too small for tropical climates, due to decrease in lift with higher air temperatures. It is probable that this *M* will have to be enlarged to about the size of the *R* to be suitable for use in tropical waters.

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CHAPTER II.

NOMENCLATURE AND FUNCTIONS OF PRINCIPAL PARTS.

The names and functions of the principal parts of the type *M* kite balloon are as follows:

ENVELOPE.

The envelope, of stream line form, is the gas container.

BALLONET.

The envelope is divided into two parts by a gas-tight fabric diaphragm inside the envelope running from the tail forward and downward to a point on the bottom of the envelope about eight panels aft of the nose. The section of the envelope above the diaphragm is called the gas chamber and that below, the ballonet or air chamber. When the balloon is first inflated, the ballonet is completely deflated, the diaphragm collapsing against the bottom of the envelope. The full capacity of the envelope is used for the gas chamber.

The purpose of the ballonet is to compensate for the variation in the volume of the gas in the envelope. The ballonet increases in volume by taking in air from the outside through the scoop when the gas in the balloon contracts, and decreases in volume, the air being forced out, when the gas in the balloon expands. The scoop being exposed to the full velocity of the wind passing by the

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balloon, the air pressure at the scoop is the same as that at the nose of the balloon, consequently the pressure throughout the ballonet is the same as that at the nose of the balloon and this pressure is transmitted through the flexible diaphragm of the ballonet to the gas in the gas chamber. There is thus opposed to the pressure of the wind at the nose of the balloon an equal and opposite pressure produced by the pressure of the wind on the scoop and transmitted through the ballonet to the gas.

The ballonet diaphragm also serves to operate the automatic valve mechanism as explained later.

STABILIZERS OR EMPENNAGE.

The three thick lobes attached to the outside of the envelope at the tail are referred to by the French as the empennage and by the British as stabilizers. The lower one has a vertical position with its center line on the lowest element of the envelope and is known as the *vertical stabilizer*. The other two lobes are spaced 120° apart from this one and are known as the *horizontal stabilizers*. When the balloon is in flight, the stabilizers are filled with air and have the appearance of thick fins but when deflated they hang loosely from the envelope. The object of the stabilizers is to steady the balloon in flight and to minimize swaying both horizontally and vertically.

VALVES.

There are two valves; the top or hand operated gas valve located on the top center line of the envelope about four panels back from the nose, and the side or automatically operated gas valve located about halfway up the side slightly aft of amidships.

The top valve may be hand operated by means of a cord leading from the valve to the basket but is used only

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in cases of emergency, such as when the balloon has broken away from the towing cable and must be maneuvered as a free balloon or when a sudden release of gas is necessary. The side valve is strictly automatic in action, being operated from the ballonet diaphragm by connecting internal rigging. It takes care of the normal valve function of gas release due to increased internal pressure arising from gas expansion.

INTERNAL VALVE RIGGING.

The rigging inside of the envelope by means of which the automatic valve is operated.

RIP PANEL.

A strip or panel of fabric which is larger than the opening in the envelope over which it is placed and which is originally cemented and sewed with a single line of stitches so as to allow it to be readily ripped off and the envelope to discharge its gas quickly through a large aperture. It runs transversely across the envelope at the largest diameter and pulls off into the inside of the bag.

RIP CORD AND GLAND.

The rip cord is attached to one end of the rip panel and extends through the envelope down to the basket. It provides the means for pulling off the rip panel from the basket. The rip cord gland is a rubber gland through which the rip cord passes on its way out of the envelope. It is constructed to keep gas from leaking out along the cord and yet permits the cord to slide through when pulled.

STABILIZER RIGGING.

The rigging inside the stabilizers by means of which the stabilizers are kept in their proper shape.

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MAIN SUSPENSION BAND.

A fabric band about 6 inches in width cemented and sewed around the envelope just below the equator. It is made up complete with suspension points for bridles before attachment to the envelope and is the means of attaching the suspension to the envelope.

MOORING HARNESS.

The mooring harness supplies a means for attaching to the envelope the lines which are used to moor the balloon. The mooring harness is made of heavy braided cotton tape securely cemented to the envelope.

MOORING LINES AND PICKETING LINES.

Mooring lines are the lines used to anchor or moor the kite and are connected to the mooring harness by means of an eye splice into steel "D"-shaped rings built in the mooring harness. The picketing lines are attached to the ends of the mooring lines by means of toggles and rope eyes. They are simply removable extensions of the mooring lines and may be readily detached when the balloon is not moored.

MAIN SUSPENSION RIGGING.

The main suspension rigging is divided into two parts: (*a*) The winch suspension, which connects the balloon with the main cable leading to the ground or ship, and (*b*) the basket suspension, which connects the basket to the envelope.

WINCH SUSPENSION.

The winch suspension is divided into two sections: First, the upper section which is attached to the main suspension band and is made up entirely of rope bridles;

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and second, the lower section which is attached to the towing cable and is made up of high-grade stranded steel wire cable. The lower section is known as the "V" wires, so called from the form they take in coming to the common junction piece attached to the towing cable.

The tension in the towing cable is distributed to the envelope at 40 separate points of suspension along the suspension band, 12 points of which are located forward and 8 points aft on each side of the envelope. By a series of rope bridles these points are brought to one common point forward and one point aft on each side of the envelope. To these points are toggled the "V" wires which in turn reduce the lines of tension to one common junction point at the towing cable connection.

JUNCTION PIECE.

The connection between the end of the towing cable and the "V" wires. It consists of a bronze ring and shackle, the shackle being used for attachment to the "V" wires and the ring for supporting the towing cable.

BASKET SUSPENSION.

The rigging by which the basket is suspended from the envelope. It is made up entirely of rope and connects to the main suspension band at 32 points, 16 on each side.

There are three suspension bridle units on each side of the envelope, known as the "fore," "mid," and "aft" basket suspension units. The "fore" suspension bridle unit consists of three ranks of bridles, the first rank consisting of four bridles, second rank two bridles, and the third rank one bridle. The "mid" bridle unit consists of four ranks of bridles, the first rank consisting of eight bridles, the second four, the third two, and the fourth one. The "aft" bridle unit consists of three ranks of

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bridles similar to the forward bridle unit. The "mid" basket suspension is made up of twice as many bridles as the "fore" and "aft" suspension, since the maximum load of the basket is transmitted to the "mid" line.

SUSPENSION BAR.

A horizontal bar made of ash wood to which are attached the "fore," "mid" and "aft" basket suspension lines and six lines for attaching the bar to the basket.

AIR SCOOP.

The semiconical scoop secured to the lower vertical stabilizer. Its purpose is to supply air to the stabilizers and the ballonet. It is placed as far as possible from the envelope proper so as to obtain the full pressure from the velocity of the air passing by, which is transmitted through the stabilizers and the ballonet to the gas in the envelope to prevent the nose of the balloon from blowing in.

AIR DUCT.

A connecting fabric tube between the vertical and horizontal stabilizers for the purpose of distribution to the horizontal stabilizers of the air taken into the vertical stabilizer.

AIR OPENING INTO BALLONET FROM VERTICAL STABILIZER.

A circular hole in the envelope located five panels back from the toe of the vertical stabilizer and on the bottom center line of the envelope. It provides an opening between the vertical stabilizer and the air chamber of the envelope for the distribution of air from the stabilizer to the air chamber. It also provides a manhole for a passageway for inspection purposes.

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BALLONET APPENDIX MANHOLE.

A circular opening about 2 feet in diameter located aft on the side of the envelope below the ballonet line and used for the purposes of deflating the air chamber of the envelope and as a passageway into the ballonet for inspection purposes. It is fitted with a fabric sleeve which can be tied and made air-tight and has a cover to keep the sleeve inside and prevent air blowing the sleeve open.

INFLATION APPENDIX AND MANHOLE.

A circular opening similar in construction to the ballonet appendix, located in the nose of the balloon. It is used for inflating and deflating the gas chamber of the envelope and also serves as a manhole for entering and inspecting the interior of the gas chamber.

NURSE TUBE.

An auxiliary inflation tube entering the envelope at its lowest element just forward of the toe of the ballonet and extending along the outside bottom of the envelope thence down to the basket. It is only used from aboard ship when the balloon is in the air, and provides a means for supplying gas to the envelope after it has become flabby, without necessitating the complete hauling down of the balloon for inflation through the inflation appendix in the nose.

HANDLING LINES.

There are a total of 10 handling lines, 5 on each side. Three of these are attached on each side to the forward winch suspension, by means of a wooden toggle and rope grommet; one side line is similarly attached to the mid-basket suspension line; and one aft line on each side is carried up to the suspension band for attachment by means of three ranks of rope bridles.

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NURSE TUBE CHECK VALVE.

The check valve located at the end of the nurse tube just inside the envelope which automatically closes the inflation tube at the envelope after inflation.

NURSE TUBE DISCHARGE TUBE.

The nurse tube discharge tube acts as a secondary check valve after the valve described in the foregoing. It consists of a closed-end fabric tube constructed with circular openings for the discharge of gas. This tube covers the check valve and extends for about 6 feet along the inside of the envelope. During inflation the tube assumes full form and the gas passes freely through the discharge holes into the envelope. After inflation the loose fabric tube collapses and the discharge holes are automatically closed.

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CHAPTER III.

GENERAL DESCRIPTION AND DESIGN.

In this chapter a detailed discussion of the parts of the balloon will be taken up together with a description of their design and purpose.

1. ENVELOPE.

(Refer to pl. 3.)

The envelope proper has a capacity of 32,800 cubic feet, is 82 feet long and has a maximum diameter of 26 feet. The type *M* kite balloon with pilot and observer and necessary equipment will rise to an altitude of from 1,200 to 1,500 feet above sea level, which, although less than the altitude obtainable with type *R* kite balloons, is considered sufficient for naval purposes.

The envelope is made of two plies of rubberized cotton cloth doubled together, one ply being biased so that its warp lies at an angle of 45° to the warp of the other ply. The object of this bias ply is to prevent diagonal stretching of the fabric and to distribute the load on the fabric more uniformly, thereby stiffening the envelope and giving it a smoother and cleaner shape.

Between the two plies of cloth is a film of rubber known as the "gas film" which prevents the gas from leaking out of the envelope.

The outside of the fabric is covered with a film of rubber known as the "weather proofing" which acts as a

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preservative to the raw cloth against the weather. Over this weather proofing a film of aluminum compound is applied. Aluminum coated fabric is used in order that the envelope may radiate heat and light rather than absorb them, thus causing a more uniform temperature inside the balloon with the result that changes of the internal gas pressure due to expansion and contraction of the gas are minimized. The inside of the fabric is coated with a film of rubber known as the "inside proofing" which also helps to prevent gas leakage but which acts primarily as a protection to the raw cloth from mildew and keeps impurities in the gas from coming in direct contact with the cloth.

The construction of the envelope fabric is as follows:

	Weight in ounces per square yard.	Weight in grams per square meter.
Outside aluminum coating or rubber compound	0.7	23.7
Weatherproofing (rubber compound)	1.0	33.9
Cloth	2.5	84.8
Gas film (rubber compound)	3.6	122.0
Cloth	2.5	84.8
Inside proofing (rubber compound)	1.0	33.9
Total	11.3	383.1

The rubberized envelope fabric has a minimum breaking strength of 45 pounds per inch (8.1 kilograms per centimeter) of width in the direction of the warp of either ply and 40 pounds per inch (7.2 kilograms per centimeter) of width in the direction of the fill of either ply. Its maximum permeability to hydrogen at a temperature of 25° C., and under a pressure difference of 30 millimeters (about 1.2 inches) of water, is 15 liters per square meter (about 0.63 cubic foot per square yard) per 24 hours.

The envelope is made up of small blocks of fabric which are firmly secured to one another by cemented lap

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seams. These seams are also sewn with two rows of stitches and covered with tape inside and out. All seams are stronger than the fabric which they join.

A single block of fabric is called a panel. A gore is a section of the envelope which is bounded by two adjacent longitudinal meridian seams. A ring is a section of the envelope which is bounded by two adjacent transverse circumferential seams.

2. BALLONET.

(Refer to pl. 5.)

The ballonet fabric is similar to the envelope fabric except that there is no weatherproofing on the air side. This proofing is not considered necessary since the air side of the ballonet is protected from outside weather by virtue of its location in the interior of the envelope; and it is also free from the direct action of hydrogen gas. The construction of the ballonet fabric is as follows:

	Weight in ounces per square yard.	Weight in grams per square meter.
Air side cloth (biased)	2.0	67.8
Gas film	3.6	122.0
Gas side cloth (straight)	2.0	67.8
Gas side proofing	1.0	33.9
Total	8.6	291.5

Lighter weight cloth is used in ballonet construction since the requirement for strength is not as important as that for the envelope fabric and it is important to save weight. The requirement for permeability is the same for ballonet as for envelope fabric.

The ballonet is located aft in the interior of the envelope and runs from about the center of the tail forward and downward to a point on the bottom of the envelope

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about 8 panels aft of the nose. This location tends to insure a positive angle for high wind speeds, due to the fact that the tail is thus made air heavy and the nose gas light. The volume of the ballonet is 265 cubic meters (9,358 cubic feet) or about 28½ per cent of the volume of the envelope.

3. STABILIZERS.

The principal requirement for stabilizer fabric is that it shall be amply strong to withstand the whipping action of the wind, the requirement for nonpermeability being of little importance. For this reason and in order to conserve weight the stabilizer fabric is constructed of but one ply of cloth with inside and outside proofing as follows:

	Weight in ounces per square yard.	Weight in grams per square meter.
Aluminum coating	0.7	23.7
Outside weatherproofing	1.0	33.9
Cloth	3.5	118.7
Inside proofing	1.0	33.9
Total	6.2	210.2

INTERNAL STABILIZER RIGGING.

(Refer to pls. 6 and 7.)

This consists of a series of two diagonally crossing lines "X" and "Y" and one horizontal line "Z." These are attached to the envelope and stabilizer by means of fabric suspension bands "A," "B" and "C," constructed with built-in suspension patches similar to the main suspension band on the outside of the envelope. The rigging ropes are tied to the patches of the suspension bands by German bowline knots with the loose ends tucked between the strands of the rope. The loose end is

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not lashed in place in order to permit a ready adjustment in the length of the rigging during assembly or after flight. It is very important to inspect the rigging frequently and to make any adjustment which may be found necessary.

The stabilizer rigging serves to preserve the shape of the stabilizers and their position with respect to the envelope. The diagonal lines oppose the force of any lateral wind tending to dislocate the stabilizers.

The diagonal crossing lines are staggered so as to allow ample space between them at their intersection and thus prevent chafing or sawing due to the whipping of the stabilizers under the action of strong or puffy winds. This chafing was found to be a serious fault in the stabilizer rigging of type *R* kite balloons.

MAIN SUSPENSION BAND.

(Refer to pl. 8.)

The band is made up of one ply of canvas duck and several plies of envelope fabric to which are sewed and cemented individual patches for each suspension point. The patches are made of 1-inch herringbone tape which has an ultimate strength of 300 pounds. When built up into a patch unit as shown on plate 8 and sewed to the suspension band, the minimum breaking strength of each patch is 1,600 pounds or five times the strength of the wooden suspension sticks used on type *R* kite balloons. The suspension band is made up complete with patches and afterwards cemented and sewed around the envelope about one panel below the equator line.

The maximum load on any single suspension patch with the balloon in flight against a 60-mile head wind is calculated to be 70 pounds. The first rank of rope bridles is made of three-quarter-inch circumference Italian hemp rope of 1,200 pounds minimum breaking strength, and

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the individual patch is of slightly higher strength—1,600 pounds. It will be seen that a factor of safety of 18 is provided in the design of the rigging for type *M* kite balloons, which represents more than three times the strength of the rigging of its predecessor, the type *R*.

MAIN SUSPENSION RIGGING.

(Refer to pl. 9.)

A movable or self-adjustable rigging is provided by the use of aluminum pulley blocks in the bridles. A movable rigging has the advantage of allowing the separate bridles to adjust themselves to suit the loads transmitted to them during flight.

Considerable trouble was experienced with the first aluminum pulley blocks used due to the fact that the pulley "froze" against the pulley housing after a short time of use at sea. This "freezing" was due to the formation of an aluminum salt as a result of the corrosive action of salt water on aluminum. The design of the pulley block was therefore modified by the addition of a hub on the pulley to insure a fixed separation between pulley and pulley housing. A further precaution is taken against possible "freezing" by the application of a thin coating of grease of high melting point to both pulley and pulley housing faces.

All the rope used in the rigging is Italian hemp. It is softer and more pliable and is also approximately 50 per cent stronger size for size than Manila yacht rope. The rope rigging used on the type *M* balloon is approximately 50 per cent stronger than the rigging used on the type *R* kite balloon.

The second rank bridles in all cases are provided with double becket knot connections between pulley blocks, to allow for any adjustment or replacement in the rigging which may be found necessary after flight. Ample al-

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lowance is provided in the loose end of the connection to make an adjustment of length up to 24 inches.

The two forward bridles of the forward winch suspension will be found to chafe against the envelope. The suspension band was at first redesigned to overcome this objection, by lowering its location on the envelope; but this opened up many more serious difficulties and it was finally found to be more satisfactory to provide strips of outside envelope tape over the areas subject to chafing after the balloon had been in service a sufficient length of time definitely to mark these areas. The operator must therefore look for this chafing to develop and provide for it accordingly.

TOP GAS VALVE.

(Refer to pl. 2.)

The top gas valve is hand operated by means of a cord leading from the valve to the basket *and is used only in case of emergency* such as when the balloon has broken away from the towing cable and must be maneuvered as a free balloon or when sudden release of gas is necessary.

SIDE GAS VALVE.

(Refer to pls. 10, 11, and 12.)

The side gas valve performs all the normal functions of gas discharge and is strictly automatic in action, being operated from the ballonet by connecting internal rigging. (Refer to pl. 10.)

The valve rigging is intended to open the valve when the ballonet diaphragm is down to the lowest point—the ballonet being empty—and yet not to cause this opening, if at that moment the nose of the balloon should be momentarily forced in on account of a sudden gust of wind striking it.

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The internal rigging connecting the valve to the ballonet consists of two side lines (one of which is attached to the valve) which extend from opposite sides of the envelope to a common point in the center of the envelope and a longitudinal line which runs continuously from the nose of the envelope to a pulley block attached to the ballonet, thence up and through a second pulley block suspended from the common center point of the two side lines, thence down and through a third pulley block attached to the ballonet, and thence to a fixed point in the tail of the balloon. The section of the longitudinal line between the pulley suspended from the side lines and the two pulleys attached to the ballonet is compensating in length to suit certain positions of the ballonet and internal gas pressure.

Considering the nose and tail of the envelope as fixed points, it will be readily seen that after the longitudinal line is once adjusted to the proper fixed length for the conditions of: (*a*) ballonet entirely deflated, and (*b*) internal gas pressure of six-tenths of an inch water pressure (actual tests have proved this pressure sufficient to fully inflate the envelope), the automatic discharging action of the valve is entirely controlled by the position of the ballonet. As long as there is air in the ballonet the fabric is lifted and no tension can come on the two side lines. When, due to gas pressure, the ballonet fabric is forced down expelling the air from the air chamber, a condition is finally reached when any further motion will pull on the side lines. Therefore a downward movement of the ballonet at "Z," due to an increase in gas pressure above six-tenths of an inch when air chamber is free from air, is then transmitted to the metal concentration ring at "Y," which in turn pulls down on the side line connected to the valve and opens it.

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The longitudinal line may be considered adjustable in two senses; first, it can be initially adjusted in length so as to operate the valve at a given gas pressure and ballonet position as outlined in the foregoing; second, it is self-adjusting to meet certain adverse conditions encountered in flight by virtue of its connection through pulleys to the two movable points "Y" and "Z" which control the valve action. It is this latter feature which makes the valve arrangement of the type *M* kite balloon distinctive.

Consider the case of the nose caving in during flight. The internal pressure of the envelope is instantly raised, the ballonet is forced down, but the longitudinal line is reduced in length by an amount equal to the displaced position of the nose, thus compensating for the displaced position of point "Z" and allowing point "Y" to remain fixed and the valve closed. This is particularly advantageous in that the nose is almost instantly forced out due to increased internal pressure, no gas is lost, and the danger from the nose caving in is reduced to a minimum.

With a condition of balloon in flight against a head wind of 70 miles per hour, the ballonet may become fully inflated due to the wind pressure through the scoop and thus increase the internal pressure of the gas to 2.5 or 3 inches, without causing the automatic valve to operate. The increased internal pressure is necessary to keep the form of the envelope against increased outside pressure under these conditions and thus the action of the valve is self-compensating to meet this condition.

It is very important to note that only pulley blocks with zinc-plated bronze bushings are used in the construction of the internal valve rigging. Due to the difference in potential between bronze and aluminum, a strong galvanic action is set up between the bronze and

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aluminum in a phosphene gas medium. (Phosphene is often present as an impurity in commercial hydrogen gas.) This action causes the formation of a salt which freezes the pulley to the bushings. In case it is necessary to replace aluminum pulleys used inside of the envelope, care must be taken to replace only with spare pulley blocks which have galvanized bushings.

The valve is attached to the envelope by means of wingnuts tightened against a clamping ring, located on the inside of the envelope, which holds the envelope fabric between itself and the frame of the valve. The envelope is heavily reinforced with fabric around the valve hole; and on kite balloons manufactured by the B. F. Goodrich Co. the valve reinforcement contains a wedge-shaped rubber gasket constructed with it as a unit which acts as a gas-tight gasket against gas leakage. Balloons manufactured by the Goodyear Tire & Rubber Co. are equipped with separate rubber gaskets which must be placed between the metal clamping ring and the envelope fabric during assembly of valve to the balloon.

GAS MANOMETER.

(Refer to plate 21.)

A manometer which registers gas pressure in terms of inches of water pressure is located in the basket and is connected to the gas chamber of the envelope by means of a rubber tube which enters slightly above the ballonet.

AFT TOWING CABLE SUSPENSION OR AFT "V" WIRES.

If the balloon is flown while not being towed it will be noticed that the aft "V" wires will have considerable slack and the corresponding suspension bridles no tension in them. In a stiff head wind the angle of the towing

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cable to the horizontal will become smaller, the cable assuming the angle necessary to pull the aft "V" wire suspension taut. The forward "V" wires will in turn become slack which slack is immediately taken up by the balloon assuming a steeper riding angle thus overcoming the tendency to nose dive in a strong head wind.

NURSE TUBE.

The nurse tube consists of four separate parts whose functions and purposes are as follows:

(A) FOUR-INCH INFLATION TUBE EXTENDING FROM BASKET TO ENVELOPE.

(Refer to pl. 13.)

The inflation tube represents the main lead for the gas from the connecting gas line aboard ship to the gas chamber of the envelope. It is fastened to the outside bottom of the envelope at regular intervals by means of fabric slings cemented around the nurse tube and to the envelope. Besides serving as an attachment of tube to envelope the slings also serve to prevent twisting and consequent closing of the tube during inflation.

(B) QUICK ATTACHMENT COUPLING AT BASKET END OF NURSE TUBE.

(Refer to pl. 14.)

This coupling is located at the basket end of the nurse tube which is connected to the main inflation line aboard ship. It is made of bronze and is somewhat similar in construction to a fire hose coupling. The female end is permanently attached to the nurse tube at the basket end and the male end, provided with a metal sleeve 5 inches long, is kept aboard ship available for attachment to the main gas inflation tube. The quick release or attachment coupling provides a means for reducing the time re-

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quired for making connections during inflation of the balloon through the nurse tube.

(C) CHECK VALVE AT ENVELOPE END OF NURSE TUBE.

(Refer to pl. 15.)

The check valve provides a means for automatically closing the inflation tube at the envelope after inflation. It consists of a 90° elbow made of aluminum with an open end outside the envelope for the attachment of the fabric nurse tube and a closed end inside the envelope. This closed end has a number of 1-inch diameter holes through its sides. A rubber elastic sleeve incloses the discharge end of the valve. During inflation the elastic sleeve expands and allows gas to discharge through the 1-inch holes. After inflation the elastic sleeve contracts, covers the holes and thus checks the back flow of gas. A closing valve located at the discharge end of the nurse tube is distinctly better than one located at the intake end, inasmuch as an area of diffusion represented by the length of the tube from the envelope to the basket is eliminated.

(D) DISCHARGE TUBE OR HOOD INSIDE OF ENVELOPE.

(Refer to pl. 16.)

The gas leaving the check valve discharges into a loose fabric hood or tube which incloses the check valve and is cemented on all sides to the envelope. It extends for a distance of about 6 feet forward of the valve and has eight 3-inch diameter holes for discharge of the gas. During inflation the hood assumes full form and the gas passes freely through the discharge holes into the envelope. After inflation the loose fabric hood collapses and the discharge holes are closed. Thus a second check valve is provided against gas leakage through the nurse tube.

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RIPPING PANEL.

(Refer to pl. 17.)

The ripping panel is located on the top of the envelope near the section of the largest diameter. It is used in emergency only when a rapid deflation is desired, and is operated by tearing off the panel proper which consists of a strip of envelope fabric cemented and sewed to the envelope. The gas escapes through a series of elliptical holes in the balloon which are exposed by removal of the panel. The holes are reinforced to prevent the envelope from being distorted when the panel is torn off.

The panel is ripped by means of a cord attached to a wooden toggle in one end and run down inside the envelope through a series of breakable string guides to the rip cord connection or gland on the envelope, thence through the gland to the basket where it is made fast to the concentration bar within easy reach of the pilot. When used, the cord should be given a strong jerk to break the string attachments, then pulled with a steady force.

BASKET.

(Refer to pl. 19.)

The basket is built of high-grade rattan and is designed to give maximum flexibility combined with great strength. The top of the basket is roughly oval in shape, the sides flaring out to a wider and larger bottom. This allows added space in the bottom of the basket for the storage of ballast. The ends are curved so as to reduce resistance to the wind. The side of the basket near the bottom is formed around a curve so as to give added strength and at the same time greater flexibility.

The suspensions for the basket consist of four end suspensions and two side or center suspensions all made of

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extra-flexible steel cable having a breaking strength of 6,300 pounds. The four end suspensions are made from one length of cable, the ends spliced together and the whole woven into the basketwork in the form of an endless line, the leads coming up the end and around a galvanized-steel thimble at the top of the basket as shown on plate 19, and the splice coming at the side of the bottom of the basket. The end lines cross one another diagonally in the bottom of the basket. The center suspensions are constructed in a similar manner and are woven into the basketwork.

The result of this type of construction is to form a basket which has maximum strength due to the interwoven cable taking all the strain of the weights during the flight; and maximum flexibility, for the reason that all the compressive strain due to hard landings is taken up by the flexible rattan only. No rigid vertical members are used in the construction of the basket. The bottom is fitted with three ash wood skids which act as protection to the rattan during handling.

SUSPENSION-BAR RIGGING.

(Refer to pl. 19.)

The suspension-bar rigging is attached to the basket in permanent eye-splices around thimbles and to the suspension bar by permanent eye-splices around the bar. The entire basket suspension rigging up to the king toggles (the toggles which connect the basket-bar rigging to the main basket suspension leads from the suspension band) is made up as a complete unit and can only be detached at the king toggles.

The reason for this is to do away with wooden toggle connections as far as possible, as the toggles are easily broken during handling and it is very difficult to obtain uniform strength in wooden parts.

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SHOCK ABSORBERS.

(Refer to pl. 19.)

The two middle basket suspensions are equipped with an auxiliary suspension line made up of elastic cord, which acts as a shock absorber. This line is adjusted in length by means of a "take-up" adjusting block made of wood and should be initially adjusted with considerable tension.

TOWING CABLE ATTACHMENT.

(Refer to pl. 20.)

The object of this fitting is to provide a means of quickly attaching the end of the towing cable to the junction ring of the "V" wires without the local loads imposed upon it by earlier methods. It is heavier in construction than former junction pieces used and has considerably greater strength.

The towing cable is wrapped twice around the drum, which is grooved so as to cause the cable to overlap and clamp against itself without depending upon the cable clamps for attachment. The drum is suspended about one-quarter off center, so as to allow the tension from the towing cable to pass directly along that side, thus putting the entire load on the overlapped cable and taking the load off the loose cable end. The cable clamps should be placed about 18 inches below the ring and clamped hand tight with a special wrench provided, but not so tight that the cable will not slip slightly through the clamp. The purpose of the design is to put the clamping action on the cable wrapping around the drum, and the cable clamps should allow slight slipping of the towing cable, so that when the tension is put on the towing cable the initial adjustment can take place. Any direct clamping action of the cable clamps will prevent this initial adjustment and nullify the purpose of the design.

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CHAPTER IV.

METHOD OF CONSTRUCTION.

A brief outline of the method used in the construction of kite balloons by the Goodyear Tire & Rubber Co. and the B. F. Goodrich Co., at Akron, Ohio, follows:

All cloth used for balloon fabric is run over an inspection table where it is inspected for flaws and blemishes which are cut out or, if the flaws are too numerous, the defective cloth is discarded.

The raw cloth is then coated with rubber by what is known as a "spreading machine." The rubber compound is placed on the cloth in successive layers until the required thickness of film is built up. Usually about 20 coats are spread on the cloth and very frequently more. Up to a certain limit the greater the number of coats of rubber spread on the cloth for a given weight of rubber per square yard the better the gas-tightness.

Envelope and ballonet fabrics for kite balloons are made up of two plies, one of which is a bias ply and the other a straight ply. The straight ply which is the outside ply of the finished fabric is finished in the spreading machine with several very thin coats of a mixture of aluminum powder in rubber.

For the construction of the bias ply, straight fabric is taken to the bias cutting table where it is cut at an angle of 45°, in lengths to correspond to the width of the straight ply of fabric. Each cut section is then turned

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at an angle of 90° and the edges cemented together making one continuous length of bias fabric, the width of which corresponds to the width of the straight fabric.

The straight ply and the bias ply of fabric after rubberizing are placed together forming a two-ply fabric in a "doubling machine." This machine is very similar to an ordinary clothes wringer, the upper roller of which carries the outer or straight ply of fabric, and the lower roller the inside or bias fabric. As the two plies pass between these rolls, the rubberized surfaces are brought into contact and are firmly pressed together.

The two-ply fabric is then wound round a large iron drum, wrapped with cloth, and placed in the steam curing vat where it is cured or vulcanized.

The finished fabric is then run over a "light table" and all flaws or defects thus detected are marked at the time to be afterwards cut out or patched.

After the fabric has been inspected and tested it is ready to be cut into panels for assembly. Sixteen thicknesses of fabric are laid out for about 50 feet, there being 16 gores in the envelope. Cardboard patterns are then placed on the fabric in a manner to give the greatest economy of fabric. The outline is marked for cutting, after which a three-quarter inch seam lap allowance is marked. Curved edges are placed across the fabric and straight edges along the fabric. The panels are then cut with an electrically driven cutting machine known as the universal reciprocating cutter, type Agile. The cutter consists of a razor blade which moves up and down at a very high rate of speed, the holding frame of which is moved forward by hand. After the panels have been cut they are marked for assembly. Edges of panels which are to be cemented together are marked similarly so that when assembling the envelope it is only necessary to match up the assembly marks on the panels. The panels

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are then buffed along the seam lines with a wire brush in order to remove loose aluminum flakes and dust so as to provide a good base for the cement. The buffing is done by hand and extreme care is taken not to buff so deep as to expose the raw cloth or cut away the rubber coating.

Up to this point the process of manufacture is the same at both the Goodyear and the Goodrich factories. The method of assembly of the panels, however, is different, the Goodyear Co. using what is known as the sectional assembly and the Goodrich Co. the gore assembly.

At the Goodrich factory the panels are laid out in the order of their assembly for one complete gore extending from nose to tail. Panels containing accessories such as valve flanges, manometer glands, valve glands, etc., are constructed as far as possible before assembly in the gore. The panel seams are swabbed with benzine to remove any foreign matter, then given three coats of cement, each coat being allowed to dry thoroughly before applying the succeeding coat. Under no circumstances is fanning permitted to hasten the drying of cement as this is detrimental to a good cemented lap. The third coat of cement is not permitted to dry thoroughly but only until the cement becomes "tacky." The cemented edges are then lapped together, allowing for 1 inch overlap, and thoroughly rolled down.

The panels of a gore are so assembled that the bias fabric of two adjacent panels oppose one another. This provides for opposing directions of the warp of the bias fabric in adjacent rings of the envelope and is done to counteract the tendency of the balloon envelope to twist spirally during stretch. After a complete gore has been cemented together the laps are sewed by two rows of lock stitching, six to eight stitches per inch, spaced one-fourth of an inch apart and equidistant from the center line of the seam. The machine used is a one-fourth-inch

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gauge, lock-stitch Singer sewing machine, type 11–30, and the thread is Richardson's size "D" silk thread lightly coated with glycerine.

After sewing, the seams are covered with single bias tape on both sides, the outside tape being $1\frac{7}{8}$ inch wide and the inside $2\frac{5}{8}$ inches wide. The seams should be coated with three coats of cement, as outlined in the foregoing for lapping of seams, before applying the tape. The tape is then applied, thoroughly rolled down, and soapstoned. It is not stretched but laid loosely upon the seam, which is pulled tight (refer to pls. 4 and 5). It is essential that all taping be evenly applied so as to cover the stitching and edge of lap by a good margin, since the purpose is to prevent diffusion at the seams due to the holes of the stitching.

After all the gores have been cemented, sewed and taped, the next operation is to assemble the gores into two sections. The sections consist of two halves dividing the envelope one panel off its top and bottom longitudinal center lines, making seven gores in one section and nine gores in the other. This division of one panel off center line is made in order to allow the almost complete location of the vertical stabilizer on the half section before final assembly of the halves. The gores for a half section are laid out on a long table, given three coats of cement along the meridian lap edges and assembled together. The procedure of cementing, sewing and taping is the same as for panel assembly.

The half sections are then spread on a canvas covered floor, and the locations of stabilizers, ballonet, suspension band, etc., marked thereon. The stabilizers are then cemented, sewed and taped on their respective half sections. The two halves are next cemented and taped along the bottom seam line only, the top seam being left open to permit passage of the sewing machine during the

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final sewing of suspension band, ballonet, etc. The suspension band and ballonet are then cemented on the envelope, sewed and taped in like manner. The final seam is sewed by the sewing machine through the top valve opening on the envelope. The rip panel is assembled one half on the nine-gore section, before final assembly of the two half sections. The other half of the rip panel is assembled to the envelope after the final top seam is closed and is accomplished in a similar manner to the sewing of the final seam.

The mooring harness is next assembled to the envelope by cementing and taping only.

A brief outline of the "sectional" method of assembly used at the Goodyear factory is given in the following:

The envelope is divided up into 16 minor sections—i. e., sections 1a, 1b, 2a, 2b, etc.—eight of which go to make up a major section or half section (refer to pl. 26). The half sections are top and bottom sections, the division being made along the equator line. The closing seam therefore is along the side of the balloon instead of along the top as at the Goodrich factory.

After the panels are cut from the patterns and marked for seam lap, they are sorted into minor sections and placed in separate bins. Each section is built up as a separate unit, the routine of buffing and applying the cement being the same as at the Goodrich factory. After a minor section has been cemented together the laps are sewed by two rows of chain stitching, six to eight stitches per inch, spaced ¼-inch apart and equidistant from the center line of the seam. The machine used is a Union special ¼-inch gauge, double needle, chain stitch, sewing machine. No. 30 Clark's O. N. T. left twist thread is used for the top and No. 50 O. N. T. left twist thread is used for the under thread.

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Single bias tape, $1\frac{5}{8}$-inch, is cemented to both inside and outside seams. Valve reinforcements, gland reinforcements, tie patches, etc., are assembled to the minor sections before final assembly.

After all the minor sections (1a, 1b, etc.) have been cemented, sewed, and taped, they are assembled into top and bottom half sections as follows:

TOP HALF SECTION.

1. Section 1a is assembled to 1b, 2a to 2b, and 4a to 4b by cementing, sewing and taping along the longitudinal seam.

2. The after section of the ballonet (refer to pl. 27) is next assembled to section 4 of the envelope (equivalent to 4a and 4b).

3. Sections 3a and 3b are separately assembled to section 4 by cementing, sewing and taping along ring seam 26–27.

4. The lateral lobes or stabilizers, which have been built up separately, are next assembled to sections 3a, 3b and 4. It will be noted that the seam between 3a and 3b is left open to permit of easy access for handling the sewing machine while sewing on the stabilizers. It will be further noted that sections 4a and 4b are made 5-gore widths wide between rings 29, 30 and 31, in order to permit the complete assembly of the stabilizers to sections 3 and 4 before the final top and bottom half sections of the envelope are assembled.

5. The seam is closed between sections 3a and 3b.

6. The rip panel is assembled to section 2 (2a and 2b) by cementing, single sewing and taping.

7. Section 1 is joined to section 2 and finally sections 1–2 and 3–4. The top half is now completely joined. The mooring harness, which has been built up complete as a separate unit, is now cemented and taped to the top section.

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BOTTOM HALF SECTION.

1. Section 5a is assembled to 5b making section 5; likewise 6a is joined to 6b, 7a and 7b and 8a to 8b.

2. Section 7 is joined to section 8 and the rudder or vertical lobe assembled to these sections.

3. Section 6 is joined to sections 7 and 8.

4. The "mid" and forward sections of the ballonet are cemented, sewed and taped to sections 6, 7 and 8.

5. Section 5 is joined to sections 6, 7 and 8, making a complete lower half section of the envelope.

6. The main suspension band is next cemented, sewed with two rows of double stitching and taped to the lower half section.

7. The nurse tube and internal valve rigging is assembled, thus making the lower half section complete with accessories.

The top and bottom half sections are then cemented and sewed in steps of ten panels at a time until the equator seam is entirely closed. The nose disk is first cemented and then sewed by operating the sewing machine through the manhole in the nose. The tail disk is partly sewed by machine and at the last by hand. The balloon is now completely closed.

8. Connect the ballonet sections by cementing inside the envelope. There is no sewing in the ballonet except at the connecting seam between envelope and ballonet.

Of the two methods of assembly described, there is no advantage of one over the other in so far as quality of workmanship is concerned, but there is a distinct advantage gained in the use of the sectional assembly method when production is vital, as with this method several independent operations can be carried on at the same time, thereby increasing the production of the balloons and also lowering the cost for a single balloon.

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A brief outline of specifications to be followed in the construction of type *M* kite balloons is given in the following:

FABRIC WORK.

Seams.—All outside seams should first be buffed lightly with a wire brush so as to remove the flaky aluminum coating and to expose the underlying rubber base. Extreme care should be taken not to brush away the rubber coating under the aluminum nor expose the underlying raw cloth. It is essential that the outside rubber coating of the fabric be preserved as far as possible in order to secure a good cemented joint.

All fabric parts to be cemented, including seams, valve reinforcement, suspension band, etc., should be covered with three successive coats of cement, each coat being allowed to dry thoroughly before applying the succeeding coat except the last one which is allowed to dry only until the cement becomes "tacky."

Lap allowance for seam construction on the envelope, stabilizers, and ballonet is three-fourths of an inch.

The sewing may be either a chain or lock stitch, spaced one-fourth of an inch apart, six to eight stitches per inch and located in the center of the lap. In case the stitching runs off the lap the threads should be removed, the section retaped, and resewed. The sewing may be done with a ¼-inch gauge lock-stitch Singer sewing machine, type 11–30, or a ¼-inch gauge chain stitch, Union Special sewing machine. With the former, use Richardson's size "D" silk thread and with the latter No. 30 O. N. T. left twist thread for the top thread and No. 50 O. N. T. left twist thread for the bobbin. The needle used is a No. 3 spear point but this may be modified by stating that a needle of the finest point possible for the size of thread

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should be used. With the chain stitch the rough side of the sewing should come on the inside of the fabric.

Ballonet seams are cemented and taped but not sewed except the connecting seam between ballonet and envelope. This sewing is the same as described for general seam construction.

All seams which are sewed are afterward taped. Single-ply bias tape is used both inside and outside of the envelope. Balloons constructed by the Goodyear Co. use tape $1\frac{5}{8}$ inch wide both inside and outside whereas those manufactured by the Goodrich Co. use inside tape $2\frac{5}{8}$ inches wide and outside tape $1\frac{7}{8}$ inch wide. The tape should be applied evenly over the laps with the envelope fabric under tension and the tape loose. Care must be taken to see that the tape extends beyond the lap at least three-eighths of an inch on either side when using tape $1\frac{5}{8}$ inch wide and a corresponding increase of margin for the wider tapes.

Main suspension band.—The suspension band is made up of four plies of envelope fabric cemented together. The becket patches or crows feet are formed of herring-bone tape 1 inch wide, having a minimum breaking strength of 300 pounds. Each finger of the patch is made up of two lengths of tape 10 inches long and seized into a ring for 2 inches at the bottom as shown on plate 8.

After the suspension band is made up complete it is sewed to the envelope with two rows of double stitching the same as is used in seam construction. The sewing is covered by tape on both sides.

Mooring harness.—The mooring harness is formed of nonelastic cotton tape, $1\frac{1}{2}$ inch wide, having a minimum breaking strength of 720 pounds. The tape is first soaked in rubber cement for about 24 hours until thoroughly saturated. The patches which hold the "D" rings are then sewed to the tape and the harness made up complete

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before assembly to the envelope. It is attached to the envelope by cementing and taping only.

Rip panel.—The rip panel is made up of the reinforcing strip which is cemented, sewed and taped to the envelope, and the panel which is cemented to the reinforcing strip with lap allowance of 1½ inch and then sewed with single stitching clear through the reinforcing strip and envelope. The sewing is afterward covered with 1⅝-inch tape.

Rigging.—The outside rigging is made up of the following size ropes and cables:

Location.	Size.		Material.	Minimum breaking strength.
	Number.	Circumference.		
		Inches.		*Pounds.*
First rank	3	¾	Hemp	1,200
Second rank	4	1	do	1,870
Third rank	5	1¼	do	3,300
Fore and aft basket suspension	A	1½	do	3,960
"V" wire suspension	A	1½	do	3,960
Mid-basket suspension	B	2	do	5,940
Handling lines		2	Cotton	2,000
"V" wires		Diam. ⅜	Steel cable 7 by 19.	14,400

NOTE.—Hemp rope in accordance with Bureau of Construction and Repair Aeronautical Specification No. 117.

All rope splices should have five tucks served with waxed Andover harness thread for about two tucks back from the end of the splice.

Wire splices should be in accordance with the Roebling 6-tuck wire splice served with No. 60 blocking cord or Andover harness thread for about 3 inches back from the end of the splice. The serving should be varnished.

When the balloon is completely assembled it is ready for final inspection. It is partially inflated with air, and one man goes into it while another follows his progress from the outside. Together they go over every

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panel and seam in the balloon, inside and out, to make sure that there are no holes, defective spots, or loose places. All such places are repaired by patching, recementing or, if necessary, by substituting an entire new panel or section. This last is very unusual, as such gross defects are generally discovered before this stage in the production is reached. In like manner, the location and good condition of all attached parts are checked; toggles, splice lashings, and connections are thoroughly inspected and the rigging checked for length.

Following is a brief outline of the inspection operations used by the superintending constructor at the Goodyear and Goodrich factories at Akron, Ohio:

(A) TOP OUTSIDE.

1. *Inflation sleeve or appendix.*—Inspect carefully where sleeve is joined to envelope, and also see that the inflation cover is a good fit.

2. *Top of envelope.*—The top of the envelope should be carefully inspected for proper sewing and taping. All wrinkles in the tape should be rolled out, but if this is not possible the tape should be lifted and recemented. Care should be taken to see that all tape covers the stitching with a margin of about three-quarters of an inch.

3. *Mooring harness.*—The mooring harness should be properly cemented and taped to the bag, that is to say, there should be no evidence of the harness having been applied taut over a loose envelope. Chafing patches should be located under the "D" ring connection to the mooring harness and also at the intersections of the harness.

4. *Rip panel.*—Inspect the rip panel for location on the envelope, sewing, taping and connecting cord, being particular to see that none of the operating parts is missing or foul of any other part.

5. *Insignia.*—Inspect for location and workmanship.

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(B) SIDE STABILIZERS.

1. *Outside.*—Inspect for cementing, sewing and taping of seams, defects in fabric, and general appearance and shape.

2. *Inside.*—Inspect inside of stabilizer fabric for cementing, sewing and taping of seams, and defects in fabric.

3. *Rigging.*—The stabilizer rigging must be carefully checked with the drawings, allowing ½-inch variation in lengths of ropes; all knots must be tightly drawn, strands of rope opened, and ends tucked in but not lashed. Care must be taken to see that no line fouls another and that the suspension bands have been properly located. When the stabilizer is fully inflated there should be a marked clearance between diagonal ropes. If these ropes touch, the rigging is wrong and adjustment is necessary.

4. *Air ducts, drain holes, etc.*—Inspect the air ducts for location, taping, etc. Care should be taken to see that the necessary drain holes and deflation holes are in their proper location and in accordance with the workmanship required.

(C) BOTTOM.

Inspect seams as outlined in the foregoing; check location and cementing of insignia and Navy number.

(D) OUTSIDE RIGGING.

Each section of the rigging should be checked for length and sewing and splicing inspected for defective workmanship. All splices must have five tucks. The rigging should be carefully inspected for defective toggles and pulley blocks.

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(E) BALLONET.

Enter the air chamber by the manhole appendix on the side of the envelope and inspect the ballonet for defects in fabric, cementing, sewing and taping of seams.

(F) ENVELOPE INSIDE.

1. Inspect the gore assembly for alternate arrangement of the direction of the warp threads in the bias ply. Make the usual inspection of fabric and seam construction.

2. The rip panel cord must be tied with breakable string guides at all rip panel patches and along the inside of the envelope to the gland.

3. Check the location of accessories such as the rip cord, rip cord gland, manometer gland, valves, etc.

4. Connect the top and side valves to the envelope and attach the internal rigging to the automatic valve. Inflate and test the internal valve rigging, i. e., see that the automatic side valve opens at six-tenths of an inch water pressure with the envelope on an even keel. If the valve opens at a higher or lower pressure than six-tenths of an inch make proper adjustment in the length of the longitudinal line at the tail end of the balloon.

All ropes of the spider patches connecting the internal valve rigging to the envelope must be taut when the envelope is under pressure, otherwise adjustment should be made.

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CHAPTER V.

SHIPMENT.

CLASSIFICATION.

The equipment comprising a complete kite balloon shipment is classified as follows:

(A) ENVELOPE.

Comprising nearly all the necessary working parts assembled to the envelope at the factory with the exception of certain metal parts, "V" wires, manometer tubing, basket, etc., which are assembled at final erection.

(B) PARTS ERECTED AT FINAL ASSEMBLY.

Such parts as gas valves, nurse tube check valve, metal clamping rings for valves, "V" wires, manometer tubing, manometer, picketing lines, basket, etc., which are not assembled to the envelope at the factory, in order to prevent injury to the parts as well as to the envelope fabric during shipments. These parts are assembled to the balloon during final erection, preparatory to putting the balloon into service.

(C) ACCESSORIES.

Such items as ground cloth, sand bags, inflation tube, sleeves, etc., which are not actual working parts of the balloon in the air and are therefore not permanently assembled to it.

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(D) SPARE PARTS.

Representing 25 per cent of the actual requirements of rope, pulley blocks, toggles, etc., used in the balloon construction which are shipped as extra material to be used in making necessary replacements and repairs.

(E) REPAIR MATERIAL.

Necessary equipment, cementing materials, etc., for making repairs to the balloon.

LIST OF CASES.

The complete balloon equipment is shipped in five cases which are all marked plainly on the outside showing the balloon number, type, displacement, weight, case number, total number of cases in the shipment, name of the manufacturer and the destination.

Following is a list of the cases comprising a shipment together with their contents:

Case No. 1. Envelope Trunk.

Outside dimensions, 39½ by 39¼ by 75½ inches.
Displacement, 68 cubic feet.
Gross weight, 1,370 pounds.
This case contains the following items which are assembled to the envelope at the factory, then packed in a rubberized packing case:

Envelope.
Ballonet.
Stabilizers.
Gas inflation appendix.
Air inflation appendix.
Air scoop.
Air ducts connecting stabilizers.
Stabilizer deflation sleeve.
Insignia.
Rip cord.
Rip panel.

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Rip cord gland.
Valve reinforcements.
Hand maneuvering valve cord and gland.
Internal valve rigging with spiders and all parts complete.
Main suspension band with patches.
Main suspension rigging complete to bar rigging.
Mooring harness.
Mooring ropes.
Stabilizer internal rigging.
Manometer tube gland.
Nurse tube with attachments, reinforcing collar and patches.

Case No. 2. Valve Trunk.

Outside dimensions, 31 by 28¾ by 28¾ inches.
Displacement, 14.8 cubic feet.
Gross weight, 156 pounds.
This case contains the following parts:
One 16-inch Caquot type valve complete, No____.
One 16-inch Caquot type valve complete, No____.
1 can of flake graphite.
24 spare wingnuts.
2 spare valve gaskets.
6 spare valve springs.

Case No. 3. Accessory Trunk.

Outside dimensions, 59 by 30 by 30 inches.
Displacement, 30.7 cubic feet.
Gross weight, 521 pounds.
This case contains the following accessories:
1 ground cloth.
10 cotton rope handling lines.

Case No. 4. Accessory Trunk.

Outside dimensions, 22 by 23 by 46½ inches.
Displacement, 13.5 cubic feet.
Gross weight, 312 pounds.
This case contains the following: (*a*) accessories, (*b*) parts assembled at final assembly, (*c*) spare parts and repair equipment as listed below:

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(A) ACCESSORIES.

1 set of supplementary "V" wires.
1 inflation tube 6 inches diameter, 90 feet long.
1 right-angle inflation sleeve.
2 straight inflation sleeves.
50 sandbags complete with hooks.

(B) PARTS ASSEMBLED AT FINAL ERECTION.

2 sets of forward "V" wires complete with attachments.
2 sets of after "V" wires complete with attachments.
1 nurse tube check valve.
16 picketing lines.
1 manometer tube.
1 manometer tube connection.
1 manometer.
1 reducing sleeve for connection to nurse tube at basket end.

(C) SPARE PARTS.

10 sandbag hooks.
4 No. 2 wood toggles.
4 No. 3 wood toggles.
1 No. 4 wood toggle.
1 No. 5 wood toggle.
1 No. 6 wood toggle.
8 No. 6A wood toggles.
45 feet three-eighths-inch 7 by 19 cable.
10 feet three-sixteenths-inch manila yacht rope.
5 No. A galvanized-iron thimbles.
2 No. B galvanized-iron thimbles.
2 No. 8A galvanized-iron thimbles.
2 No. 6 galvanized-iron thimbles.
1 No. 5 galvanized-iron thimble.
4 No. 1 galvanized-iron thimbles.
24 No. 3 aluminum pulley blocks.
6 No. 4 aluminum pulley blocks.
5 No. 5 aluminum pulley blocks.
1 No. 3 aluminum pulley block (zinc-plated bushing).
1 No. 5 aluminum pulley block (zinc-plated bushing).
200 feet No. 3 Italian hemp rope.

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150 feet No. 4 Italian hemp rope.
30 feet No. 5 Italian hemp rope.
70 feet No. A Italian hemp rope.
10 feet No. B Italian hemp rope.
1 ball of No. 24 blocking cord.
1 pint of manometer oil and dropper.
1 spare manometer glass.
1 No. 5 patch.
10 yards envelope fabric.
10 yards stabilizer fabric.
5 yards ballonet fabric.
50 yards outside tape.
50 yards inside tape.
12 rolls of friction tape.
1 spare shock absorber rope-adjusting block.
25 yards herringbone webbing tape.
15 feet ⅛-inch rubber coated cable for internal valve rigging.
2 box wood plates for internal spiders.
2 Goodrich rubber plugs for rip cord and valve glands.
2 balls of breakable twine.

(D) REPAIR MATERIAL.

2 fabric rollers.
2 yachtsman's knives.
2 flashlights.
2 batteries.
2 bulbs.
2 fabric stitchers.
1 cement can.
20 pints of cement.
2 gallons aluminum compound in one-half gallon cans.
3 benzine swabs.
1 package No. 14 needles.
2 cement brushes.
1 package No. 16 needles.
1 spool 150 yards No. 30 O.N.T. thread.
1 spool 150 yards No. 50 O.N.T. thread.
½ pound beeswax.
½ pound talc.
2 sewing palms.

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Case No. 5. Basket Trunk.

Outside dimensions, 49½ by 68 by 49½ inches.
Displacement, 82.3 cubic feet.
Gross weight, 296 pounds.
This case contains the following:

One basket complete with two seats, pockets, map case, suspension bar with shock absorbers, and rigging attached up to and including the middle, forward and aft king toggles.

2 valve covers (assembled to valves at final erection).

1 30-foot rope ladder (accessory).

The foregoing list is subject to revisions from time to time to agree with new developments of design and new requirements found in service, and therefore must not be considered an infallible list but rather as a guide as to what to look for in a kite balloon shipment.

In packing this material care is taken to see that none of the material can shift and become damaged or damage other parts of the shipment in transit. In packing the envelope the following procedure is used:

First. All metal parts, cables for attachments inside and outside of envelope, which would be liable to chafe or otherwise injure the fabric in transit are wrapped in scrap fabric or burlap.

Second. The suspension rigging is rolled up to the suspension band and wrapped in burlap, forming a compact roll along the edge of the band.

Third. The envelope is spread flat on the floor with top side up, top center seam line in the center and suspension band on the under side of the extreme port and starboard edges.

Fourth. The envelope is folded together as follows: First fold the nose toward the tail by two panels so that the apex of the nose coincides with the fourth ring seam; then fold the extreme port and starboard edges toward the center line by one gore so that the edges coincide

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with the first gore seam from the center seam; fold the new edges toward the center seam by one panel so that they coincide with the center line. The envelope now being folded to a width equal to two gores, make final fold and reduce to the width of one gore.

Fifth. The envelope is rolled up starting from the tail and rolling as tightly as possible toward the nose.

Sixth. The balloon is placed in the waterproof packing case and the case is securely tied up. A strip of fabric is placed over the top of the packing case and tightly cemented down, sealing the whole package against water and moisture.

The envelope should never be packed in a sealed case of this kind unless all fabric and cordage is perfectly dry and cool, otherwise the balloon may be severely damaged.

When a balloon is to be stored for any length of time a dry place of moderate temperature is preferable. Heat and moisture are injurious to the fabric, cordage, and many of the accessories.

Keeping the trunks moisture proof is as important as keeping the envelope dry when it is put in the trunk. Never use bale hooks to handle trunks.

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CHAPTER VI.

UNPACKING, ASSEMBLY, AND INFLATION.

No attempt will be made to discuss the procedure on board ship since the facilities there are limited and it is doubtful whether even under most favorable conditions the detailed procedure could be thoroughly carried out. It will be assumed that the balloon has been sent to a naval station, and is thence transferred aboard ship after assembly and inflation.

Upon the arrival of the balloon at its destination, all trunks and crates are carefully inspected from the outside to ascertain whether they have been damaged during transit. They should then be opened and the contents examined for damaged parts and checked against the inclosed shipping lists for missing parts.

An outline of the operations to be followed in the assembly and inflation of the balloon is given in the following:

1. GROUND CLOTH.

Select a position for the ground cloth which is free from low overhead or side obstructions which might interfere with the balloon after it is inflated. Spread out the ground cloth, care being taken to see that it is free from loose pieces of dirt or gritty foreign matter which would be injurious to the balloon.

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2. LAYING OUT ENVELOPE.

Take the envelope package from its trunk, remove it from the packing case and spread it on the ground cloth, keeping in mind the fact that the envelope was originally rolled up from tail to nose and that unrolling should be started from that point on the ground cloth which heads in the direction that it is desired to head the balloon in. The envelope should be unrolled from a starting point on the ground cloth about 7 feet back from the leading edge in order to allow for the unfolding of the nose of the balloon which was originally folded toward the tail a distance equal to the width of two rings.

3. ASSEMBLY OF VALVES AND MANOMETER TUBE TO ENVELOPE.

(A) *The manually operated top valve* (pl. 2) is attached by first inserting the metal clamping ring and rubber gasket through the valve opening and fitting the metal studs of the clamping ring through the corresponding holes in the gasket and the envelope valve reinforcement. The valve cord is then attached to the valve by looping through the metal ring provided on the valve for this attachment. The valve is then fitted over the protruding metal studs of the clamping ring and clamped in place with wing nuts.

Attention is called to the fact that the above operation is described for a Caquot valve as supplied with kite balloons manufactured by the Goodyear Tire & Rubber Co. The procedure remains the same for valve attachment to balloons manufactured by the B. F. Goodrich Co. except that the inside rubber gasket is omitted, it being built in the valve-opening reinforcement as a unit.

(B) *The automatic side valve* (pls. 10, 11 and 12) is attached to the envelope in a similar manner to the fore-

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going. Care must be taken not to omit the attachment of the operating cord to the valve before fitting the valve over the outside studs and clamping in place with wing nuts.

(C) *The nurse tube check valve* (pl. 15) is attached to the envelope by means of a metal clamping ring and wing nuts in a manner similar to the attachment of the gas valves. The nurse tube is then attached to the outside end of the check valve by slipping the fabric over the elbow and securing in place by taping. The outside section of the nurse tube attached to the bottom of the envelope is protected by an outside fabric covering which is provided with a laced cover near the check valve. This cover is left open when the balloon is shipped from the factory but must be laced in place after the check valve has been attached.

(D) *Manometer tubing and manometer* (pls. 2 and 21).—The manometer is filled by removing the cap screw and filling the tube with red manometer liquid until it appears in the glass tube at about the zero point on the scale. Then adjust the zero point on the scale opposite the top of the column of liquid by loosening the adjustment screw and moving the scale up or down to the proper position, being sure that the vent in the top is open to the atmosphere. The adjustable index should then be moved to the point at which it is desired to have the valve open (six-tenths of an inch). Next remove the plug from the manometer tube connection on the balloon and attach it to the manometer tube. Attach the other end of the manometer tube to the manometer by slipping it over the brass tube connection at the top of the manometer.

4. AIR INFLATION AND INSPECTION.

By the foregoing operations the balloon has been made air-tight and also means have been provided for register-

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ing the internal pressure of the envelope. The envelope should now be inflated with air and inspected internally as outlined in Chapter IV. All necessary repairs should be made at the time.

A trial should then be made of the internal air pressure necessary to open the automatic valve. (Refer to the construction and operation of the automatic valve outlined in Chapter III.)

The envelope is inflated until the automatic valve begins to open. A man stationed inside the envelope registers this opening by shouting to a man stationed on the outside who reads the manometer, and calls back the gas pressure. If the manometer registers a pressure above six-tenths of an inch the length of the longitudinal valve line is adjusted at the tail of the envelope by taking up a few inches in the rope end just aft of the boxwood plate of the suspension spider. (Refer to detail at "X," pl. 10.)

The adjustment on this rope end of the longitudinal line consists of a sliding Turk's head knot held in place by a wooden peg placed between the rope strands and securely lashed. In order to adjust the length of the longitudinal line, the wooden peg must first be removed by cutting the lashing, the peg reset between the rope strands at the required distance and relashed.

It is obvious that if the automatic valve releases gas at a pressure higher than six-tenths of an inch the longitudinal line must be shortened; if the pressure is lower than six-tenths of an inch at the time of release the line must be lengthened.

A variation of 0.05 of an inch above the specified six-tenths of an inch pressure is permissible and does not require adjustment of the valve rigging.

If it is not possible to air inflate the envelope, the longitudinal valve line may be adjusted from the outside

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by pulling the loose rope end of the longitudinal line through the adjustment gland in the tail of the balloon until the rubber plug is pulled clear of the aluminum core of the gland and the lashed peg exposed. Care must be taken to plug the gland hole temporarily with a piece of fabric during the operation of adjusting the length of the line. The method of adjusting is the same as described in the foregoing paragraph. After the adjustment is made the rubber plug is replaced in the aluminum core, and the pressure in the balloon raised by additional inflation until the automatic valve operates.

(NOTE.—Before testing the valve remove the burlap wrapping from the pulley blocks of the internal valve rigging and inspect for possible fouling of the lines.)

5. COMPLETION OF FINAL ASSEMBLY.

(A) Remove the burlap from the suspension rigging and any other parts which have been wrapped for protection; stretch out the rigging and see that all lines stretch clear without fouling.

(B) Attach the handling and picketing lines and "V" wires to the rigging by passing the toggle ends through the respective attachment eyes in the main rigging.

(C) Attach the "V" wires to the main towing cable by means of the special main junction piece shown on plate 20, as follows:

Remove the saddle clips "CC," pass the end of the cable around the drum "A," starting at "X," the side nearest the shackle, and, leading this cable around the deep groove, follow around, crossing the first turn at the top. Allow a loose end of about 5 or 6 feet and secure temporarily to the standing part.

Clamp "D" should then be fitted in position with its upper edge about 18 inches below the drum "A," the

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aluminum clip to lie between the two parts. The nuts securing the clamp are to be tightened *only* with the special socket wrench "W" provided, which is so formed that only a small leverage can be brought to bear, thus preventing the bolts being drawn up too tightly. If these nuts are screwed up to such an extent as to prevent the cable slipping slightly, the purpose of the attachment will be nullified and the drum will act only as a thimble.

The cable should be eased around the drum until the standing part continues approximately the center line of the shackle "B," and the saddle clips "CC" should then be replaced.

A second clamp "S" should be secured as shown about 8 inches below the first, but a bight should be left in the part of the free end between the two clamps to allow the upper clamp to move into the correct position.

The balloon is now ready for gas inflation.

6. GAS INFLATION.

(A) First fill about 80 sand bags three-quarters full of dry sand and distribute them about the envelope. The officer in charge should carefully inspect the manometer to see that the zero point is properly adjusted and that the connections to the tubing and attachment to the envelope do not leak.

(B) Fasten a few picketing lines to their respective stakes or rings on each side of the balloon and distribute about 50 sand bags around the suspension, hooking them to the first row of bridles.

(C) Connect the inflation tube and the inflation appendix by drawing both tubes over the inflation sleeve. In order to secure a gas-tight joint, draw the inflation tubing entirely over the sleeve and tie securely with tape at the end of the sleeve nearest the balloon; then draw the inflation appendix tubing entirely over the sleeve

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and tie with tape the end of sleeve farthest from the balloon. Great care should be taken to see that this connection is tight and that all inlets and outlets, such as valves and glands, are closed, since the process of inflation draws in air if any opening exists.

The inflation tube should be run under a sand box equipped with a tripping arrangement so that the hinged bottom can be instantly released and a large quantity of sand allowed to fall on the tube, thus instantly cutting off the flow of gas in case of fire. This sand box should be located near the balloon. A man should always be stationed at the sand box ready to pull the tripping cord. In addition, other men should be stationed near the end of the inflation tube which is attached to the source of gas supply. These men should have an ample supply of sand instantly available, and should in addition be equipped with large sharp knives with which to cut the tube free from the source of gas supply in case of fire breaking out at any point in the line.

If possible, a balloon should not be inflated in the open when the wind speed exceeds 20 miles per hour. If the balloon must be inflated under this condition the gas should be limited to the forward part of the balloon at the beginning of inflation by placing sand bags across the envelope. As the inflation proceeds the sand bags should be gradually moved toward the rear.

Inflation by gas bottles should not be attempted except under the supervision of an experienced man and no one should operate the valves on the bottles except under his direction. Following are a few general rules which should be strictly adhered to during inflation:

1. No smoking and no open fire or light should be permitted within 150 feet of the balloon or manifold.

2. Open fires to windward are especially to be avoided.

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3. The balloon should be placed at least 75 feet from the hydrogen cylinders.

4. Great care should be taken to prevent the inflation tube or appendix from kinking or twisting as it may be ruptured.

5. Dirt or dust should not be permitted in the hydrogen bottle or manifold connections. The presence of dirt or dust has been known to cause the ignition of hydrogen gas.

6. Valves on hydrogen bottles should be opened slowly.

7. Valves on the bottles should be tightly closed at all times except when the gas in the bottle is actually being discharged.

8. No wrenches or other mechanical means for opening or closing the bottle valves should be used. Whenever the operation can not be properly done by the attached handle, the bottle should be returned to the station where it was filled.

9. The manifold should not be moved without first closing the valves of all bottles connected to it.

10. Hydrogen bottles should be protected from the rays of the sun and exposure to heat. A safety disk is provided on each valve that will rupture when the pressure of the gas within the cylinder reaches 2,500 to 3,000 pounds per square inch. After rupture of the safety disk the issuing gas sometimes becomes ignited by reason of friction. No harm will result except in cases where inflammable material is near. For this reason inflammable material should be kept away from filled hydrogen bottles.

11. The rooms where filled bottles are stored should be provided with ample ventilation to prevent an accumulation of hydrogen if a valve leaks or a safety disk is ruptured.

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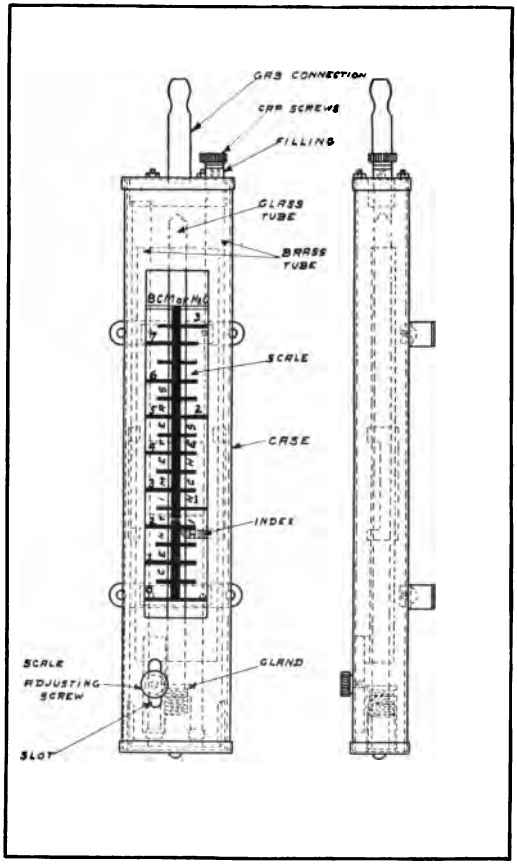

PLATE 21.—Gas manometer.

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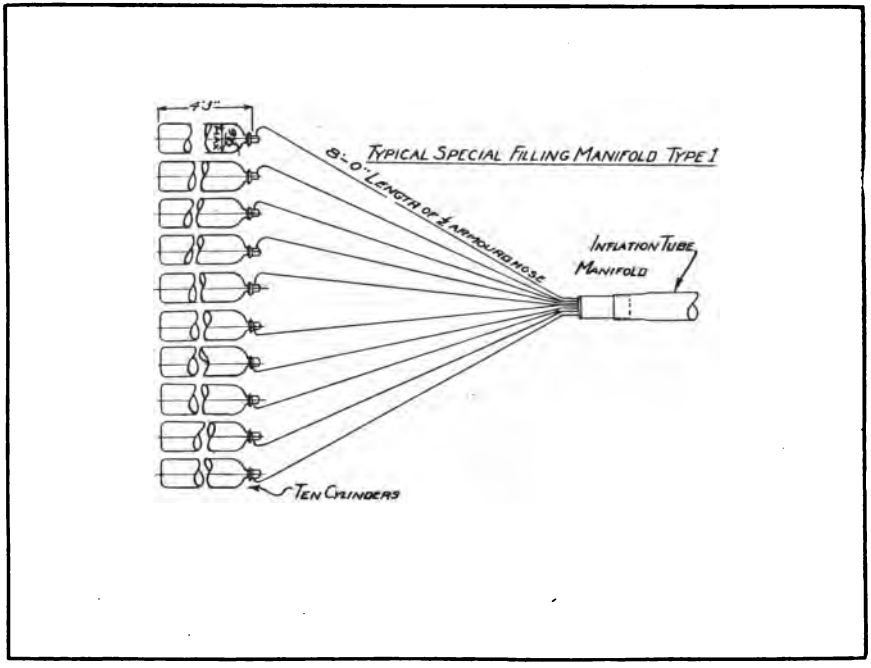

Plate 22.—Inflation tube manifold.

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There are two general types of manifolds: (*a*) low pressure, and (*b*) high pressure. A description of the low-pressure manifold, as the one more commonly used, follows:

The low-pressure manifold (pl. 22) consists of a cylinder made of a section of pipe. It is 14 inches long, and 5½ inches outside diameter, with walls about three-sixteenths of an inch thick. Screwed into the bottom are 10 nipples with 8-foot armored hose connections attached. Each hose is fitted with a cap nut which is provided in case fewer than 10 cylinders are to be discharged. The unused hose connections are plugged by means of the cap nuts.

Hydrogen cylinders should be piled in straight rows with the valves toward the inflation manifold. Full cylinders should be placed on the left and empty cylinders on the right when facing toward the pile, the valve ends being nearest the observer. Whenever possible empty cylinders should be separated from full cylinders by not less than 10 feet and empty cylinders should be piled in line with the full ones. Signs made of wood or metal not less than 12 inches square should be placed on each pile to indicate whether cylinders are full or empty. A large sign with red letters on a white background should be placed near the cylinders to give warning against smoking or carrying of flame within 150 feet of the notice. Cylinder caps should be left on full cylinders and empty cylinders at all times except when cylinders are connected to manifold. Great care must be exercised to prevent the mixing of full and empty cylinders.

Cylinder caps should in no case be left on top of piles of cylinders or on the ground. *Valves on empty cylinders must always be left closed* and under no condition should the valve on a full cylinder be opened in a hangar.

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Every precaution should be taken to insure the complete emptying of cylinders. Manifold connections should never be removed from cylinders until all valves are closed, as, with atmospheric pressure in the cylinders, air very quickly replaces the hydrogen if given an opportunity. Cylinders with air in them involve extra work at the charging plant and introduce an element of danger. Cylinders should not be blown by cracking open the valves before connecting to the inflation device. This practice has been the cause of many fires and is not worth the risk involved. Care should always be taken, however, to examine the valve outlets of cylinders to ascertain whether there is foreign matter in the valve outlets.

If hydrogen becomes ignited, the use of liquid extinguishers should not be attempted. Sand will be much more effective.

As the balloon inflates, let out the picketing lines and gradually move the sandbags from the upper to the lower bridles. When the bottom of the balloon has reached a point about 5 feet from the ground hold the balloon in position. At this height the valve adjustment should be made if found necessary. The gas flow should be continued until the pressure at which the valve should operate automatically is reached. If adjustment is found necessary, the length of the longitudinal line of the internal valve rigging should be shortened or lengthened, as the case may require, by changing the position of the knot behind the boxwood plate as previously explained in Part 4, "Air inflation and inspection," of this chapter. This knot can be reached from the outside by means of the gland in the tail of the envelope. When the knot has been adjusted so that the valve automatically opens at the required pressure the valve should be inspected to see that it reseats without leaking after opening.

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7. ATTACHMENT OF BASKET TO ENVELOPE.

The balloon is allowed to rise slowly by releasing on the picketing lines with the men stationed as shown on plate 23. As the balloon rises the sandbags should be removed from the suspension and the balloon held by the handling lines with men stationed as shown on plate 24. The picketing lines should then be removed.

(*a*) Bring the basket to the proper place underneath the balloon and load with 16 full sandbags. The attachment of basket to suspension rigging is made by passing the king toggles of the bar rigging through rope eyes of the main basket rigging.

(*b*) Attach the shock absorbers and take up any slack with the rope adjusters.

(*c*) Bring the hand valve cord and rip cord down and attach them to the suspension bar.

(*d*) Mount the manometer in a convenient place in the basket.

(*e*) Attach the loose end of the nurse tube to the suspension bar.

(*f*) Attach parachute cases to the outside of basket.

At this time a final check should be made to see that the valve and rip cords are in place, that the basket is properly attached, and that all instruments, parachutes and ballast are in place. One parachute should be carried for each observer.

If everything is found satisfactory the balloon is ready for ascension.

Several kinds of winches are employed at the present time—namely, steam, electric and gasoline. The winch most commonly used aboard ship is operated by steam.

A good type of winch has a storage drum for storing the cable not in use and two surge drums for paying out the cable. There should be about four turns of cable

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around each surge drum and some means of lubricating the cable as it is "payed" out. It is also advisable to have a meter attached to read the number of feet of cable out and another meter to register the tension in the towing cable.

For instructions on the proper operation of the winch refer to instruction books issued with standard Navy winches.

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CHAPTER VII.

INSTRUMENTS.

The usual instruments carried in a kite balloon are as follows:

Telephone.
Compass.
Anemometer.
Altimeter.
Binoculars.
Watch.

In addition to the above, maps and charts are carried, together with pencil and paper for making notes.

The telephone is connected to a conductor running up through the center of the main cable or by separate wires. If separate wires are used they lead from the basket to the "V" wires and then drop free or are attached to the main cable at the bottom by an insulated attachment to prevent them from blowing around and becoming tangled or fouled.

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CHAPTER VIII.

DESCENT AND ANCHORAGE.

Upon signal from the basket of the balloon, the cable should be pulled in and the deck crew should take their places preparatory to receiving the balloon.

The ordinary speed of descent is about 400 feet per minute. It is possible to haul down at 1,000 feet per minute but descent at such a speed is bad for the fabric and rigging, and also throws an excessive strain on the cable.

When the maneuvering lines come within reach, the men should catch hold of them and haul them in just fast enough to keep them taut and not slack up the cable or let the balloon change its riding angle. When the basket comes within about 10 feet of the deck stop the winch until the basket stops swinging before bringing the basket to the deck. When the junction shackle is within 10 feet of the main pulley the winch should be stopped. Several cables have been broken by pulling the junction shackle into the main pulley. It is a good idea to put a distinguishing mark on the cable at the point where it is desired to stop.

If it is necessary to bring the balloon down farther, the men should all work together to pull the balloon down to the required position by man strength alone, using a short hand-over-hand pull.

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If the balloon is not required any more, the picketing ropes should be fastened on, the "V" wires unfastened from the junction shackle and the basket detached. If the balloon is to be picketed (see pls. 23 and 24), the maneuvering ropes should be detached, sand bags attached in the suspension and the picketing lines attached to their fastenings on the deck. In a light breeze the balloon can be anchored fully assembled and ready for flight, but unless it is necessary it should not be left in the sun for any length of time. Under such circumstances care should be taken that it is in a clear space so that it can swing in case of a change of wind, and sufficient sand ballast should be put in the basket to keep the balloon steady. If the wind is strong or the balloon is to be left for a considerable time it should be dismantled as described below and picketed.

Spread the ground cloth and clean it. Bring the envelope down close to the ground cloth with the nose in the wind. Plenty of ballast should be put in the rigging and the picketing lines should be securely fastened to their stakes. Let the air escape from the ballonet and stabilizers and cover the valves. The rip cord should also be fastened with slack to one of the picketing stakes so that if the balloon should break away the rip panel will be torn off and the balloon will not be lost.

After a day's work it is usually necessary to replenish the gas supply to make up for the loss during operation and to restore its purity. For the balloon to operate satisfactorily, the purity of the gas should not fall below 90 per cent. During this operation the same precautions in regard to lights and leaks should be taken as during inflation. The picket ropes should be loosened as the gas flows in. Gas should be added until the normal working pressure is restored. By normal working pressure it is

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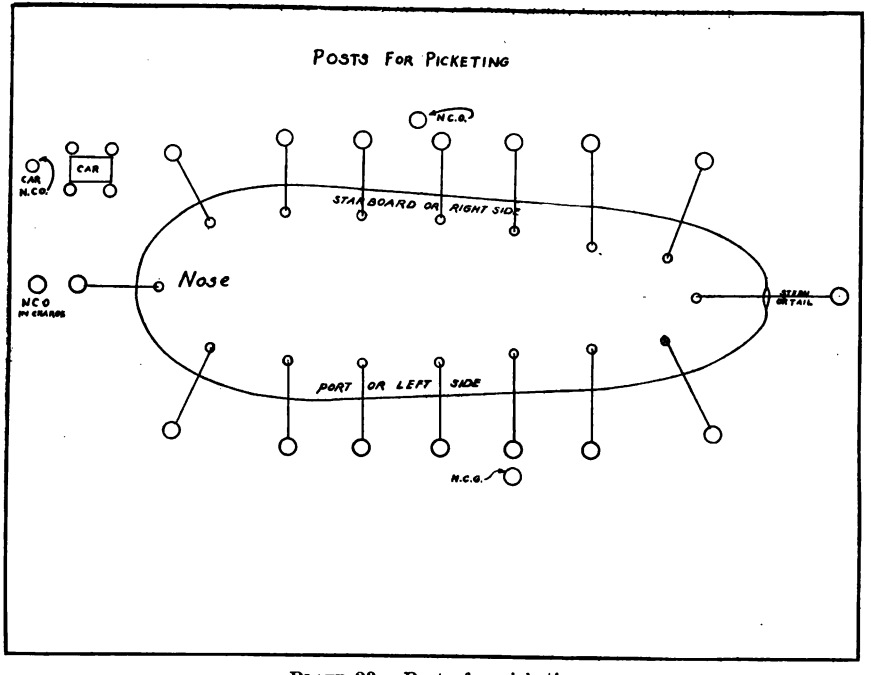

PLATE 23.—Posts for picketing.

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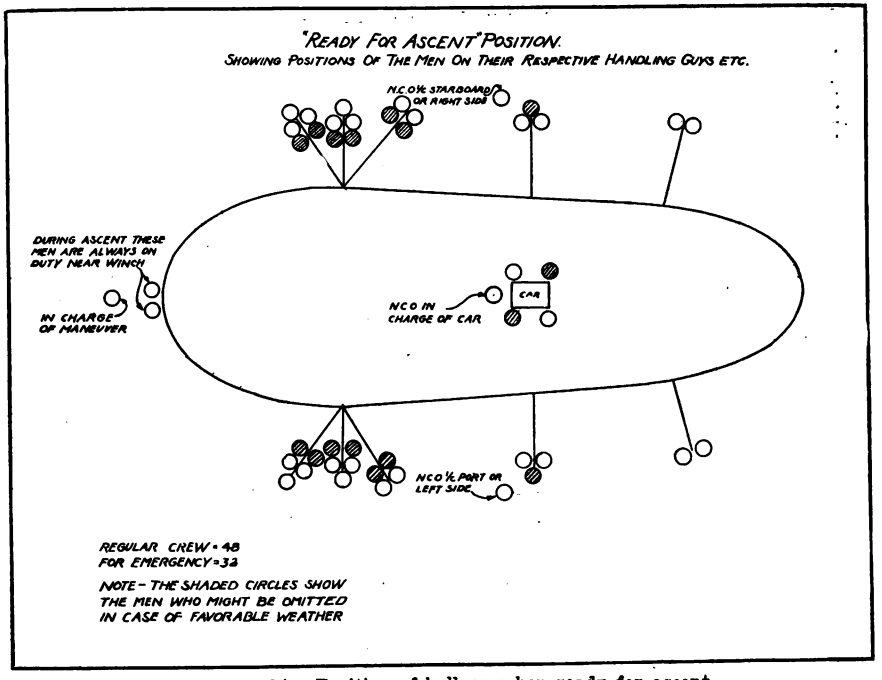

PLATE 24.—Position of balloon when ready for ascent.

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not meant that the balloon should be filled until the valve blows.

Economy in gas is largely dependent on the judgment that is used in putting it in. Allow about 1,000 cubic feet for each 1,000 feet of altitude to be attained plus a small allowance (about 300 cubic feet) for expansion due to heat if the gas is added at night.

If the manometer is held at the bottom of the balloon it should read about one-tenth of an inch. Usually about 1,750 cubic feet of fresh gas are required. If the amount of gas required exceeds this, examine the valve and its connections. See that it seats absolutely tight and is set to open at the proper time. Examine the glands, inflation appendix and rip panel. Remember that one hole one-sixteenth of an inch in diameter will let out more gas than escapes by diffusion through the entire fabric of the balloon.

The greatest care must also be taken to prevent air from getting in. Gas can always be replaced but the only way to get air out is to deflate. With good management this should not be necessary for at least two months. The quality of the gas should be tested daily if possible and if it is found to be lower than 90 per cent pure, the balloon should be deflated and, if the low purity was due to the age of the gas in the envelope, it should be reinflated with fresh gas. If the low purity was due to leaks, the envelope must be inspected and the leak found and repaired.

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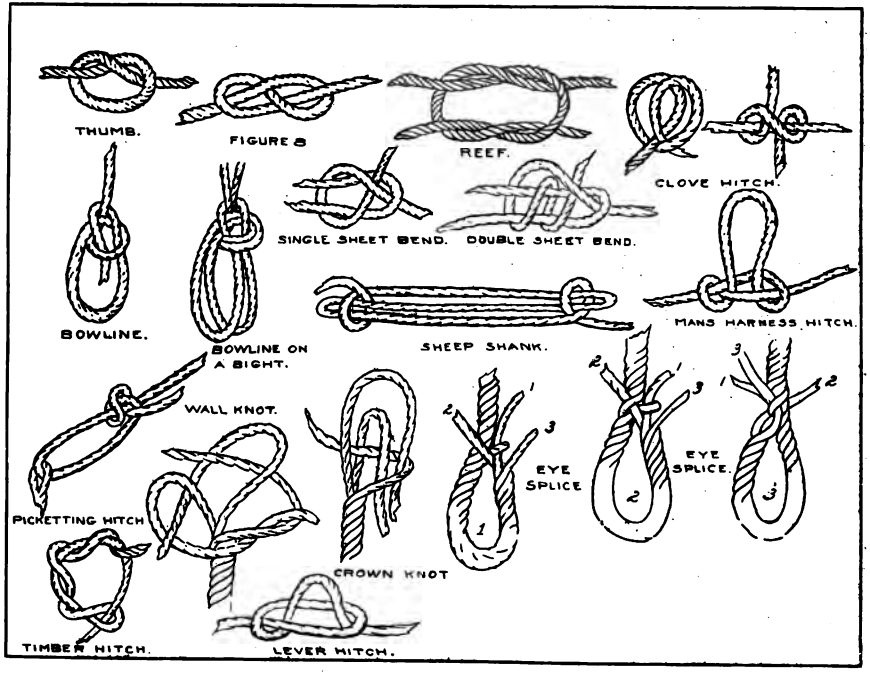

PLATE 25.—Knots.

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CHAPTER IX.

INSPECTION, REPAIR, AND STORAGE.

If the balloon is deflated at any time it should be inflated with air, inspected and repaired. If it is to be stored, the valve and cords should be detached and the balloon should be folded as described in Chapter V, and stored in a shaded place well protected from the rays of the sun.

The air inflation can be done by a hand or a motor-driven blower. There are in use at present several types of motor and hand operated blowers. A good hand type should fill the balloon in not more than 1 hour and 30 minutes.

The balloon fabric should be inspected carefully at frequent intervals for holes, deep scratches and scuffed places. Examine the balloon particularly where it comes in contact with the ground underneath the lobes and where the ropes are liable to chafe. Such places should be carefully patched. To patch these places cut out a piece of fabric of the proper kind and large enough to cover the damaged spot completely. Wash the surface of the balloon and the patch with gasoline on a cloth and apply two light coats of cement (tire cement will do if there is no balloon cement available) to each surface. Allow the cement to dry until it will not come off on the back of hand and then apply the patch and roll it down firmly against some hard smooth surface. Special care should be taken to make the edges tight. The cement will dry better and more rapidly and will stick more securely when the atmosphere is warm and dry. Put the patch inside if possible. If the patch is put on the outside of the envelope the surface should be lightly buffed to

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roughen the aluminum coating before applying the cement.

To detect pin holes and other causes of small leaks, the envelope should be partially inflated with air and inspected from the inside, panel by panel. By this means small holes are readily seen against the light. This should be done after every deflation. (Do not forget to remove the shoes or put on special shoes before going inside the balloon.)

If the rip panel has been used and must be reinserted, it will be necessary to partially inflate the balloon, as the rip panel is applied on the inside. The balloon should be inflated in such a position that the rip panel opening is down against the ground cloth. Clean the old cement off with gasoline and remove the sewing from the balloon and rip panel. Examine the reinforcement strip and the reinforcing around the holes for any edge which may have pulled loose with the panel. Any such places should be cemented and rolled down. Cement the balloon and panel with three coats each and allow to dry as above. Then put the panel in place, starting at the bottom and working up toward the top on one side, being careful not to stretch the top edge out of place. Roll the panel down hard. Then put the other side of the panel down in the same way. Try the panel at the top to see that it pulls off properly and cement it down again. When finished there should be a 1½-inch lap cemented all around the panel. The panel point should be cemented down just beyond the grommet that permits accumulated water to drain. Cement and tape over the edge of the panel on the inside of the envelope and, when completed, soapstone all cemented surfaces well. Do not roll the balloon up for several hours.

(Note.—The rip panel is originally sewed to the bag, but after once being ripped sewing can not be done. A cemented seam is sufficient to hold the panel in place.)

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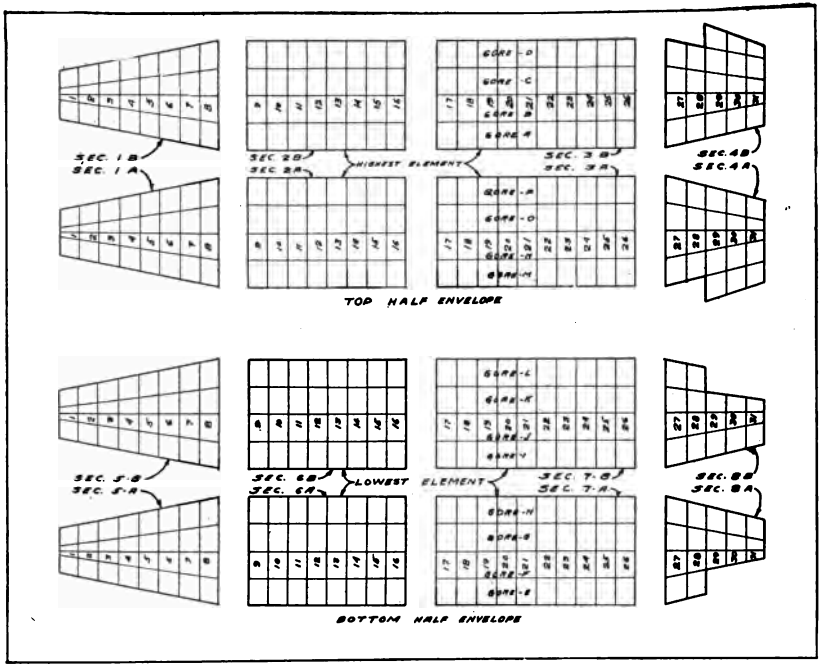

PLATE 26.—Assembly of envelope by sections.

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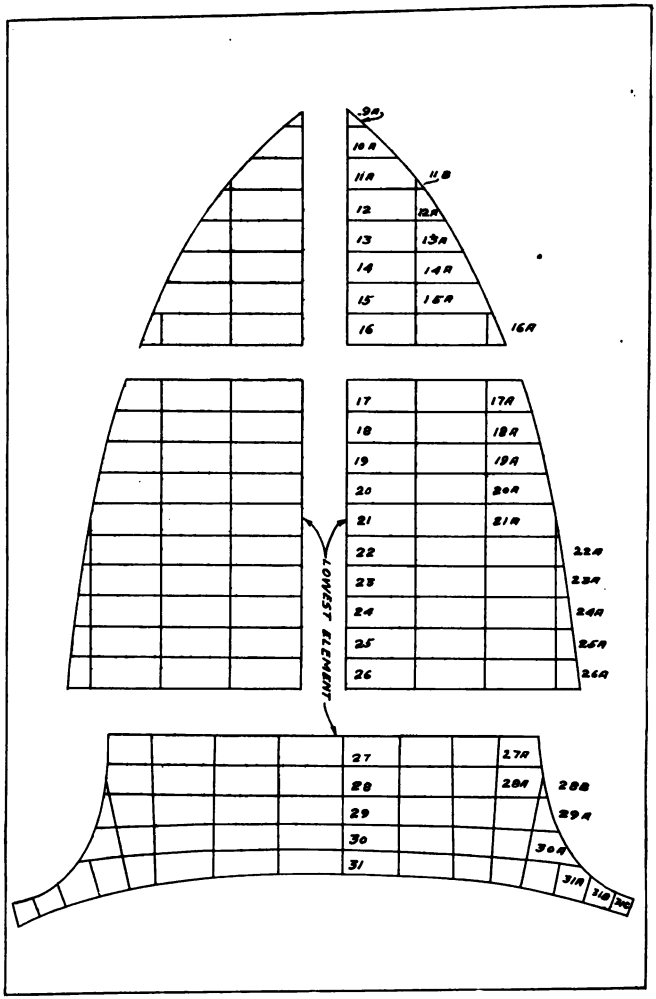

PLATE 27.—Assembly of ballonet by sections.

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The surface of the balloon should be cleaned. If any oil gets on the surface wash it off at once with gasoline. For washing the balloon or for thinning cement always use high-test benzine, energine or gasoline free from the heavier hydrocarbons. Always be careful about using such cleaning fluids over seams. Ordinary dirt can be removed with water. If it is wished to paint any part of the balloon, such as scuffed places, a specially prepared paint which will not injure the fabric should be used.

All attachments on the envelope should be carefully examined to see that they are firmly in place and do not leak, and all taping and seams should be gone over to see that they have not loosened up. The suspension band should be examined to see that the crows feet have not loosened and all damaged places should be immediately repaired. Loose tape, seams, or fabric attachments should be recemented.

The suspension should be gone over rope by rope and splice by splice. Any worn places should be immediately renewed. This inspection should be made daily when the balloon is inflated regardless of whether the balloon is flying or not.

The main cable and pulley should also be inspected daily. Inspect the loop and splice where the cable connects on the junction shackle with particular care. Never substitute cable clamps or other patent devices for holding the cable if a new loop is to be made. Use only a splice made by an experienced rigger. The main cable has a breaking strength of about 14,000 pounds and even in a wind as high as 60 miles per hour the strain on it never exceeds 6,000 pounds, so that, if kept in good condition, it is perfectly safe. If the main cable starts to wear it may be kept in use by reversing end for end, but great care must be taken that it does not chafe at any point.

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The valves should be inspected daily (whether the balloon is flying or not). The automatic adjustment, the pressure at which the automatic valve opens and the direct pull required to open either valve should be checked. Care should be taken to see that the frame is not chipped, that the dome seats properly and is not warped or bent and that the gasket has not become brittle or cracked. The threads on the wing nuts and studs should be examined and all wing nuts and washers should be in place. If the valves are inspected while the balloon is inflated, never touch them until first having touched the fabric of the balloon. *This rule should apply to touching any metal fixture on the balloon when it is inflated.* Static discharges from persons touching metal parts without first "grounding" themselves have caused the explosion and loss of balloons.

When parachutes are not in use, remove them from the containers and suspend them so that they hang freely at full length with the cordage down. This keeps them in good condition and reduces handling to a minimum. The parachutes used in an ascent should be freshly packed just before going out. Before packing they should be carefully examined. Inspect for broken stitches, holes, tears, tears around grommets, rough eyelets, chafed, worn, or deteriorated ropes, broken lashings, loosened reinforcements, cracks in the bar and general deterioration. Also see that the case is smooth on the inside. *When in doubt do not use the parachute.*

If the balloon is to be repacked in the trunks follow the procedure outlined in Chapter V, making sure that all parts are packed and that nothing can shift in transit. Special care should be taken in packing a balloon after use to see that it is dry and free from dirt inside and out and that nothing is left in it which would injure the fabric.

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Plate 2.—GENERAL ARRANGEMENT OF BALLOON.

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Plate 2A.—ARRANGEMENT OF MOORING HARNESS ON ENVELOPE.

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Plate 3.—GENERAL ARRANGEMENT OF ENVELOPE.

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Plate 4.—ENVELOPE PATTERN DRAWING.

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Plate 6.—STABILIZER INSIDE SUSPENSION ROPES.

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Plate 7.—DETAILS OF STABILIZER INTERNAL SUSPENSION.

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Plate 8.—DETAIL OF MAIN SUSPENSION BAND.

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Plate 9.—GENERAL ARRANGEMENT AND DETAILS OF MAIN SUSPENSION RIGGING.

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Plate 10. — GENERAL ARRANGEMENT AND DETAILS OF INTERNAL RIGGING FOR AUTOMATIC VALVE.

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Plate 11.—CAQUOT VALVE USED ON GOODYEAR KITE BALLOONS.

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Plate 12.—GAMMETER VALVE USED ON GOODRICH KITE BALLOONS.

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Plate 13. — GENERAL ARRANGEMENT AND ATTACHMENT TO ENVELOPE OF NURSE TUBE.

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Plate 14.—NURSE TUBE QUICK RELEASE COUPLING.

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Plate 15.—NURSE TUBE CHECK VALVE.

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Plate 16.—NURSE TUBE DISCHARGE TUBE INSIDE ENVELOPE.

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Plate 17.—RIPPING PANEL.

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Plate 18.—RIPPING PANEL CORD AND GLAND.

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Plate 19.—SUSPENSION BAR RIGGING.

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Plate 20.—MAIN JUNCTION PIECE.
BALLOON.

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